CORRECTING ENERGY INJUSTICE IN LOS ANGELES:
SOCIAL IMPACTS OF GRID ALTERNATIVES' SOLAR PROGRAMS

by
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A capstone submitted to Johns Hopkins University in conformity with the requirements for the degree of Master of Science in Energy Policy and Climate

Baltimore, Maryland
December 2019

Executive Summary

Certain climate change responses have the potential to be mitigation strategies as well as adaptation plans. These solutions can also have secondary effects that benefit populations economically, socially and environmentally. This report explores one such solution in the US: low-income solar programs. The study partners with GRID Alternatives, a national nonprofit organization that focuses on energy equity programs.

One of GRID Alternative's most successful programs has been California's Energy for All program, which installs photovoltaic solar systems on low-income resident's roofs at no cost. Taking into consideration energy injustice, energy insecurity and Los Angeles' climate, this study investigates how having access to solar energy has changed Los Angeles County residents' households since installation. The study specifically attempts to determine household lifestyle changes by identifying what appliances were added or more frequently used after solar installations. The report also addresses how residents feel their utility bills have been affected by the panels. This report reflects on how solar energy influences residents' usage of climate control devices as an adaptation strategy. The study uses data from a GRID Alternatives-administered survey distributed to its Los Angeles County clients.

Results of the study show that residents reported lower electricity bills after solar panel installation. The results also show that residents capitalized on their lower electricity bills by increasing their use of air conditioning, fans and heating devices. Furthermore, residents also added refrigerators and freezers to their households — appliances which hold their own unique environmental footprints.

Keywords: Energy justice, low-income solar, distributed solar, Los Angeles County, GRID Alternatives, social determinants of health, energy insecurity, air conditioning

Acknowledgements

A special thanks to Michael Kadish, Monica Idiaquez and the GRID Alternatives team for their support throughout this project.

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1. Introduction

One need look no further than the daily news or any average climate change documentary to feel a sense of doom. Climate change is an ever-growing problem with an insufficient global remediation effort. Perhaps the most dauting aspect of climate change is its compounding nature: primary effects cause secondary effects, which lead to even more effects and consequences multiply (IPCC, 2018). Worse still, many climate change effects catalyze positive feedback loops, further burdening the Earth (IPCC, 2018). Already vulnerable populations are set to suffer multiple layers of severe consequences with the world's poor positioned to be the most impacted (IPCC, 2018). An injustice, ecosystems and communities not responsible for the current state of the Earth and who lack the ability to cope are the most harshly impacted (IPCC, 2018).

Hope persists, however. Those not resigned to climate change being an eventuality must look toward solutions that are as complex as the problem itself. These powerful and layered solutions exist and are the strategies that offer the world the best chance at redemption. Low-income solar programs within the US have the potential to be such a solution, presenting multifaceted benefits by addressing climate change mitigation and adaptation simultaneously, while also expanding social and economic advantages to vulnerable populations (Center for Social Inclusion, et. Al., 2019). This paper explores the secondary benefits of low-income solar programs in Los Angeles County, beyond their primary emission-free energy production. While low-income solar programs have numerous advantages, this paper specifically attempts to determine if residents are using solar energy to adapt to rising ambient temperatures.

This research partners with the nonprofit organization GRID Alternatives, working closely with the GRID Alternatives Greater Los Angeles office. Taking into consideration the work of

GRID Alternatives, California's potential for distributed solar, the overlap of energy injustice and energy insecurity in the US and Los Angeles County's environmental characteristics, *this study hypothesizes that after installing solar panels, low-income residents capitalize on their lower electric bills by increasing their use of climate control devices.*

2. Background

2.1 GRID Alternatives

GRID Alternatives (GRID) is the most prominent organization in the US focused on energy equity in underrepresented communities (GRID Alternatives, 2019). GRID is a nonprofit organization, founded in 2001 and headquartered in Oakland, California (GRID Alternatives, 2019). Almost all low-income solar in the US has been influenced by GRID's work — either by being installed by GRID itself, or by GRID's contribution to legislative bills, regulations, research and program initiatives (GRID Alternatives, 2019).

GRID's mission is to promote renewable energy access and energy equity programs in underserved communities and communities most impacted by energy costs (GRID Alternatives, 2019). The programs offer community members clean energy, reduced air pollution, savings on their electric bills, energy-resilient infrastructure, education and access to a growing job market (GRID Alternatives, 2019). Working closely with communities on projects, GRID is addressing social, environmental and energy justice through its programs. Their leadership in the field is serving as a model throughout the US.

GRID's model incorporates increasing renewable energy access for underserved communities though Single-Family, Multifamily and Community Solar installations while developing the solar energy workforce (GRID Alternatives, 2019). Projects are installed by a combination of GRID staff, volunteers and solar workforce trainees (GRID Alternatives, 2019). Today, GRID is the leading installer of low-income solar nationally (GRID Alternatives, 2019). So far, their programs have installed solar for over 15,000 households, provided education and training for over 43,000 individuals, installed 110 community solar projects, created an estimated $377 million in savings for homeowners and prevented an estimated 1 million tons of greenhouse gas emissions (GRID Alternatives, 2019).

GRID works heavily in California, Colorado, Washington DC and on tribal lands (GRID Alternatives, 2019). The tribal program has installed 706 systems, avoided and estimated 100,000 tons of greenhouse gases, trained 1,500 participants and created $31 million in savings (GRID Alternatives, 2019). GRID is expanding its Clean Mobility Program and has developed an international program. Today, the international program is present in Mexico, Nicaragua and Nepal and has brought solar to "schools, health clinics, homes, farms, orphanages and small businesses" through microgrid systems (GRID Alternatives, 2019). These microgrids have catalyzed economic production within international communities and contributed to a reduction in poverty through energy access (GRID Alternatives, 2019).

One of GRID's most successful programs has been the Energy for All program in California, which installs distributed solar on low-income residents' roofs at no cost.

2.2 Distributed Solar in the US

As the world transitions toward renewable energy to combat climate change, the US has found itself at a crossroads concerning its energy future. As a large emitter of climate change-inducing greenhouse gases and the global leader in per capita energy use, American has a natural opportunity to positively impact the global ecosystem by transitioning to renewable energy sources such as wind and solar for electricity (IPCC, 2018). These renewable resources offer the country unlimited domestic energy alongside the ability to mitigate the largest contribution it makes to climate change (IPCC, 2018). However, distribution of the resources, political will, economic conditions and infrastructure requirements all must align in order to successfully implement the technology.

While implementation of utility-scale renewables into the electricity grid is a bureaucratic process, distributed photovoltaic solar installations — or rooftop solar — offer Americans the opportunity to install their own renewable energy systems. These systems offset the amount of fossil-fuel generated electricity pulled from municipal electricity grids and can be a significant mitigation strategy nationally (Gagnon, Margolis and Phillips, 2016). Taking into consideration the amount of rooftop in the US and its location, the cumulative impact of national rooftop solar potential may in fact be frequently undervalued, totaling an estimated potential of 38.6% of US electricity sales (Gagnon, Margolis and Phillips, 2016). That is enough to completely replace coal or natural gas at 25% and 35% respectively (EIA, 2019a). Replacing coal with solar would lower US total carbon dioxide emissions from electricity generation by 65% (EIA, 2019b). Small buildings — residential buildings — hold the greatest portion of this potential at 25% [Figure 1].

Building Class (Building Footprint)	**Total Suitable Area (Billions of m^2)**	**Installed Capacity Potential (GW)**	**Annual Generation Potential (TWh/year)**	**Annual Generation Potential (% of National Sales)**
Small (< 5,000 ft^2)	4.92	731	926	25.0%
Medium (5,000–25,000 ft^2)	1.22	154	201	5.4%
Large (> 25,000 ft^2)	1.99	232	305	8.2%
All Buildings	**8.13**	**1,118**	**1,432**	**38.6%**

Figure 1, Estimated Suitable Area and Rooftop PV Technical Potential in the US (chart by NREL in Rooftop Photovoltaic Technical Potential in the United States, 2016)

If distributed solar has the potential to make a significant impact on US emissions, and if the majority of that impact comes from small residential buildings, should everyone install solar panels on their homes? Distributed solar potential is not evenly distributed across the US. Some states have a higher solar potential than others, the main factor of solar potential being solar radiation. Hot weather is not simply enough to create an abundant solar energy environment since humidity and cloud-cover prevent direct sunlight from reaching the ground. Resultingly, the arid states in the Southwest hold greater potential than the warm humid states in the Gulf Coast and South [Figure 2].

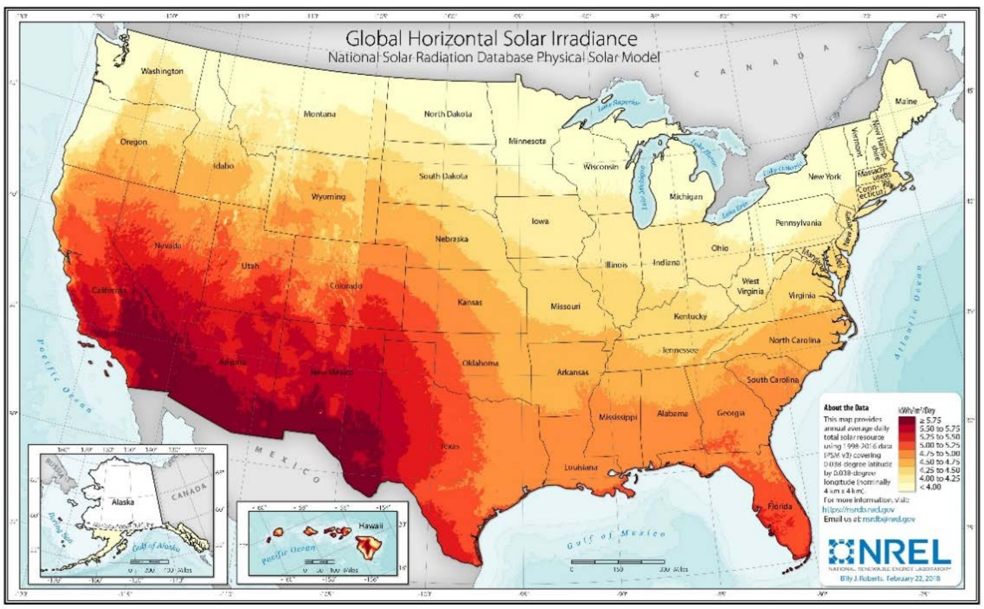


Figure 2, Global Horizontal Solar Irradiance (chart by NREL in US State Solar Resources Maps, 2018)

Further, solar radiation is not the only factor to consider in determining the areas in which rooftop solar panels will thrive. Considering the distribution of solar radiation in the context of rooftop solar means factoring in that landscapes with high solar radiation — deserts — are also often less populated than more habitable regions. These areas can be well-suited for utility-scale solar projects but do not contribute to the estimated amount that rooftop solar can add to US electricity much. Looking specifically at small buildings (<5,000sqft) suitable for solar as a percentage of total buildings it can be seen that while California, Arizona and New Mexico have high amounts of solar radiation, Louisiana, Texas and Florida have moderate levels of solar radiation with high opportunity to capture it via small-building rooftop photovoltaic systems, considering over 90% of small buildings are suitable for solar in many zip codes in these states [Figure 3].

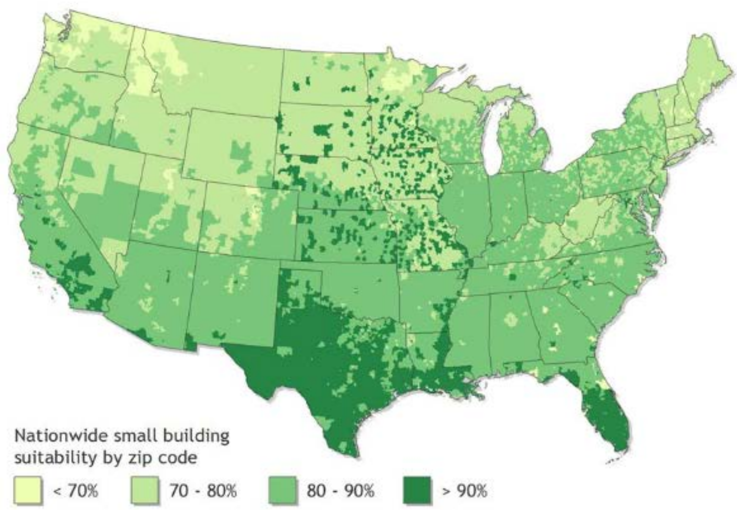


Figure 3, Percentage of small buildings suitable for PV in each Zip Code (chart by NREL in Rooftop Solar Technical Potential in the US, 2016)

The final consideration for residential rooftop solar along with solar radiation and the number of suitable rooftops is electricity demand. The United States also does not have uniform electricity needs, with some states having much higher per capita electricity use than others. Resultingly, states with relatively low solar radiative potential like Maine may not generate many megawatts via rooftop solar, but Maine may also not *need* many megawatts in the first place [Figure 4]. Combining these considerations, states where there is abundant, dry sunshine, many suitable roofs and low electricity demand are the ones with the most exciting PV potential.

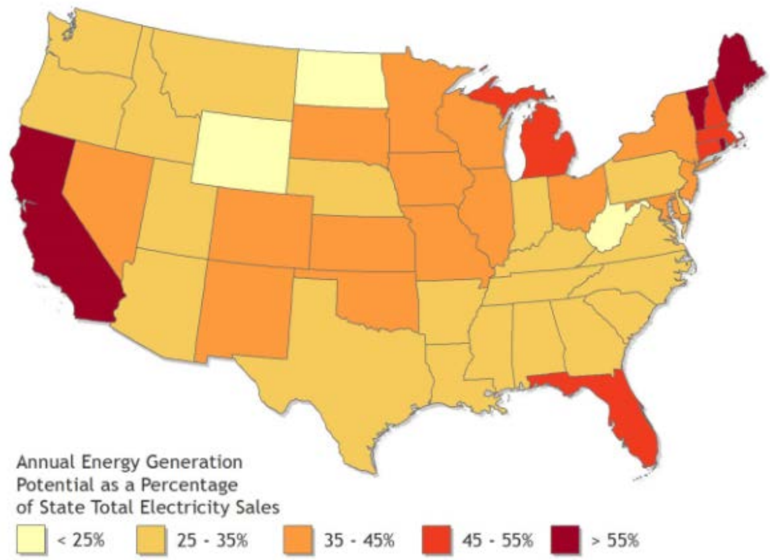


Figure 4, Solar Potential as a Percentage of State Total Electricity Sales (chart by NREL in Rooftop Solar Technical Potential in the US, 2016)

As evidenced by these factors, California's consistently temperate climate is the formative region with substantial distributed solar potential. California has some of the lowest per capita energy use in the country and the notorious sprawl of its large cities means that California also has many small-building rooftops suitable for PV installations. Resultingly, the National Renewable Energy Laboratory estimates that 74% of California's electricity could be generated by distributed solar (Gagnon, Margolis and Phillips, 2016).

Distributed solar having the estimated potential to account for 74% of California's electricity is a major statistic considering California has the fifth largest economy in the world (Associated Press, 2018). Appropriately, California is a leader in the transition to renewable energy; the State of California has set its Renewable Portfolio Standard (RPS) to be 100% renewable by 2045 (CEC, 2019). Furthermore, legislation dictates that starting in 2020 all new homes must be built to be energy efficient and must include distributed solar (CEC, 2019). In 2018, 34% of California's electricity came from renewable sources, surpassing its RPS goal of 33% by

2020, with solar being the leading renewable fuel (CEC, 2019). But how evenly distributed are the advantages of this energy system? With the great potential of rooftop solar also comes the potential to marginalize portions of the community.

2.3 Energy Injustice in the US

A fundamental advantage of renewable energy is greenhouse gas emissions mitigation, but other benefits exist concurrently. Utility bill savings is the major benefit to homeowners, drastically reducing (if not eliminating) their electric bills (Thompson, 2016). However, photovoltaic installations carry significant upfront costs for homeowners, with most residents choosing to finance the systems rather than buy them outright (Thompson, 2016). Furthermore, owning a roof previously has been a necessity to distributed solar, disadvantaging those who rent or live in multifamily buildings. Solar access from distributed systems therefore may only be accessible to the wealthy — those least burdened by utility bills but most able to pay for the systems and most likely to own their roofs.

Additionally, with fewer customers paying for the same extent of infrastructure, remaining customers suffer a rebound of increased obligation to pay for maintenance, transmission, administration and other fixed system costs (Thompson, 2016). Already, the distributed solar industry has seen the market primarily cater to middle and upper income homes (Thompson, 2016). Without programs and policies specifically designed to promote energy equity, renewable solar energy and low electricity bills may only be accessible to the upper strata of society, leaving the rest of the population overlooked.

To preempt this energy injustice issue from becoming pervasive, some states have implemented solar programs specifically designed to promote energy equity. These programs stimulate low-income solar projects, multifamily home access and community solar installations to make distributed solar more common throughout marginalized communities. Generally, they help residents with the upfront costs of solar panels and installation, often providing and installing the systems for free or at minimal cost. Residents are then able to capitalize on reduced or eliminated electricity bills.

One example is Colorado's low-income program. Colorado has been an early-adopter of low-income solar programs with the Colorado Energy Office seeking to remove barriers and provide funding to improve low-income solar access in the state (Cook and Shah, 2018). It launched an initiative to deploy 20MW of rooftop solar for low-income residents by the end of 2019 through a combination of single-home and community solar projects (Cook and Shah, 2018). Already, one main effect has been Colorado low-income residents experiencing significant relief from their energy bills (Cook and Shah, 2018). For these residents, electricity bills were previously a substantial burden, costing 6-30% of their income as opposed to 1-5% for median households in the US (Thompson, 2016). Colorado also incorporated solar photovoltaic installation into its weatherization program, another strategy that has been employed in different states (Cook and Shah, 2018). Notably, Colorado's Low Income Community Solar Project was administered by GRID Alternatives (Cook and Shah, 2018).

While Colorado serves as a foundational example of state low-income solar program implementation, California remains the national leader in thriving low-income solar programs. California has two main programs for solar equity through the California Solar Initiative, both started in 2009: Single-Family Affordable Solar Homes (SASH) and Multifamily Affordable Solar Housing (MASH) (CPUC, 2019). Both these programs target access to solar from low-income residents and development of the solar workforce (CPUC, 2019). They are the most prominent low-income solar programs in the nation and are already serving examples for other states' programs and policies. GRID Alternatives is the statewide program administrator of SASH, now under the program name, Energy for All (CPUC, 2019). It is also the program administrator of the Disadvantaged Communities – Single Family Solar Homes Program (DAC-SASH) and the solar portion of the Low Income Weatherization Program (LIWP) (GRID Alternatives, 2019). GRID Alternatives works with residents, the state, third party financers and utilities to provide and install systems to low-income Californians (SASH, 2019). During the process, GRID Alternatives provides energy efficiency training and education, system-monitoring and a 20-year warranty to homeowners (SASH, 2019). These programs are currently funded until 2021 (CPUC, 2019).

2.4 Energy Insecurity in the US

In America, where energy access is ubiquitous, energy insecurity is the most prevalent problem stemming from energy injustice. About 1 in 3 Americans is energy insecure (Berry, Hronis and Woodward, 2015). GRID's programs that promote energy equity and justice are therefore also addressing energy insecurity.

Energy insecurity is the state of not being able to utilize as much energy as would meet a household's basic needs (Murkowski and Scott, 2014). Along with lighting and cooking, a main basic need facilitated by energy is the ability to maintain a home at a reasonable temperature through heating and cooling (Murkowski and Scott, 2014). Further, climate control is the single largest energy expense on an American utility bill (Murkowski and Scott, 2014). As a result, manipulating climate control is often the first measure that households use to cope with energy insecurity.

Energy insecure households may choose to keep homes outside reasonable temperatures in order to avoid high utility bills (Murkowski and Scott, 2014). They also may choose to prioritize the utility bills over other necessities such as food, medical care or clothing (Murkowski and Scott, 2014). These households may also section off portions of their living space to heat or cool air to better afford their bills (Murkowski and Scott, 2014). All these behaviors constitute energy insecurity. The populations most affected by energy insecurity tend to be low-income, disproportionately harming minorities, the working poor and those living on a fixed income like the retired (Murkowski and Scott, 2014). Fluctuations throughout the year in energy prices may also cause some people to waver in and out of a state of energy insecurity (Murkowski and Scott, 2014). Because of the role that climate control plays within homes suffering from energy insecurity, environmental factors contribute greatly to the magnitude of burden plaguing these households.

2.5 Los Angeles' Environment

Los Angeles County is experiencing the primary climate change effect of increased average temperatures (Hall, et. Al., 2015). In a "business as usual" scenario the region is expected to rise a minimum of 4° F by mid-century (Hall, et. Al., 2015). Los Angeles is expected to triple the number of days over 95° F (County of Los Angeles Public Health, 2019). However, these changes in temperature are not uniform across the basin (Hall, et. Al., 2015).

Los Angeles in a coastal city with massive urban sprawl. The Pacific Ocean diagonally closes the city in along its west to south border and the San Gabriel Mountain Range lies to the north. The Santa Monica Mountain Range and Santa Ana Mountain Range fill in the rest of the perimeter. The economic demographics of the city are affected by this landscape — the wealthy live along the coast and median income levels drop as zip codes move centrally. Almost identically, the temperature map of Los Angeles follows these landscape and socioeconomic maps. Beach areas experience the coolest temperatures and will be least impacted by rising temperatures in the coming decades (Hall, et. Al., 2015). Upon moving inland, median incomes decrease while the temperatures increase (Hall, et. Al., 2015). These are the areas that will experience the projected hotter climate most dramatically.

Furthermore, researchers studying the Urban Heat Island effect have determined that the entire LA Basin is a heat island — or rather a "heat archipelago" (Taha, 2015). The effect means that the city is hotter as an urban area than it would be if it were the same location and climate, but natural landscape (Taha, 2015). The effect can cause upwards of 22° extra heat (Taha, 2015). In Los Angeles, an excess of concrete, sparse trees and the wall of mountains surrounding the city push hot air eastward and cause it to settle over inland parts of the city (Taha, 2015) [Figure 5]. Wealthier areas with larger yards, more parks and tree-lined streets experience the Urban Heat Island effect less dramatically. The Urban Heat Island effect parallels the way that air pollutants settle over the city due to the same factors.

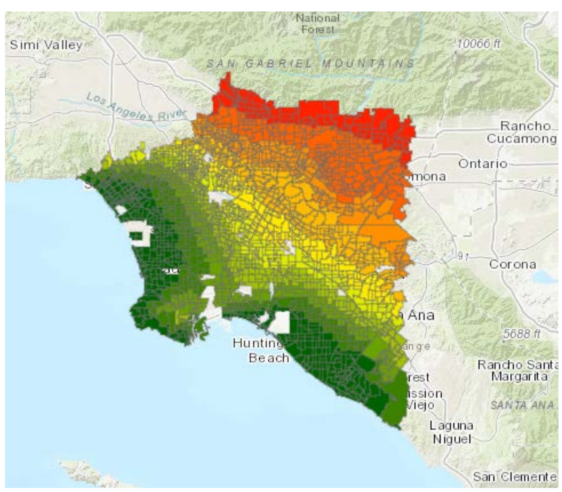


Figure 5, Los Angeles Urban Heat Island Index (map by CalEPA in Creating and Mapping an Urban Heat Island Index for California)

The result is this: central and eastern regions of Los Angeles are the hottest areas because of their natural landscape. They are made even hotter by the Urban Heat Island effect. Due to socioeconomic factors, these areas are not built with greenspace to counter the heat and are already contending with air pollution issues. Further, they are the areas that will become even hotter due to climate change. The residents of these neighborhoods are the most burdened by their energy bills and may forgo climate control devices to cope with their bills. This is also an issue of environmental injustice since these individuals likely have relatively small carbon footprints and contribute the least to climate change emissions and these are the communities that are already the most vulnerable.

This picture of the greater Los Angeles area provides a clear image of GRID's programs addressing multiple issues. The programs mitigate climate change emissions, furthering the state's renewable portfolio goal and helping address the environmental injustice to which low-income communities are subjected. The programs provide job training for marginalized communities in the rapidly expanding local solar industry, promoting empowerment through economic development. They mitigate air pollutants, cleaning Los Angeles' notorious smoggy skies and promoting better public health. They also provide homeowners with financial savings in neighborhoods where lower monthly bills can have the largest impact.

Since the low median income Los Angeles zip codes where GRID works are also the areas that experience the highest temperatures, the areas that will experience in the future even higher temperatures and are the areas where energy insecure residents are not able to use their climate control devices as freely as they want, this study hypothesizes that after installation, residents increase usage of climate control devices. If residents are using their solar panels to acclimate to a rise of ambient temperature, then GRID is providing them with a climate change adaptation strategy along with a mitigation plan.

3. Methods

The study aims to explore a) how residents feel their solar panels have affected their electricity bills b) did residents buy any new appliances since installing their solar panels and which appliances were purchased c) did residents increase their usage of their existing appliances and if so, for which appliances.

The purpose of this study is to determine what happens on an individual household scale after GRID Alternatives installs solar panels — specifically focusing on the addition of appliances in order to speculate on lifestyle changes. The study also makes a distinction between households adding appliances and households using existing appliances more. Results heavily focus on the data pertaining to climate control devices (air conditioning, fans and heaters), but also considers appliances that contain refrigerants (refrigerators/freezers, air conditioners).

The study relies on the self-reported responses residents gave to a GRID Alternatives-fielded survey. The survey was emailed to program participants in Los Angeles County by GRID Alternatives. GRID Alternatives participants are qualified by the organization under the Housing and Urban Development definition of low-income, 80% or below median income. This qualification acts as a control on the population since all participants are within the same economic category. This study focuses on single-family homes to control the variable of housing unit type and size. Since this study is focused on Los Angeles County, which experiences the same climate, geographical bias was mitigated. The residents were all homeowners who had solar panels installed within the last 5 years.

The study examines how residents *feel* about their electricity bills rather than their actual utility bill data because the perception that residents hold about their bills is a more indicative input to their decision-making about electricity usage, i.e., if a homeowner feels like their bill has increased they would reduce their use of energy-intensive devices regardless of the actual utility bill measure. The results therefore are an indication of attitude rather than of an analysis on utility bills.

The survey asked residents about their average electric bill payment, the change they have observed in their average payment, if they added any new electronics or appliances to their household since the installation of their solar panels, what appliances or electronics they added, if they increased usage of their electronics or appliances and what appliances and electronics to which they attribute the increase of use.

Cultural factors can impact energy usage by influencing attitudes toward air conditioning, washing machines, dishwashers, televisions, cooking appliances and other lifestyle choices. To avoid distorting the results of the study by excluding the large Spanish-speaking population of Los Angeles County, the survey was written in both English and Spanish.

Participants were given brackets from which to choose their average electric bill:

a. Less than $180 per year ($15 per month)
b. $180 - $360 per year ($15 - $30 per month)
c. $360 - $600 per year ($30 - $50 per month)
d. $600 - $1,200 per year ($50 - $100 per month)
e. $1,200 - $2,400 per year ($100 - $200 per month)
f. Over $2,400 per year (Over $200 per month)

Participants were given brackets from which to choose the change in their electricity bills in separate questions addressing both increases and decreases:

a. $0 - $120 per year ($0 - $10 per month)
b. $120 - $240 per year ($10 - $20 per month)

c. $240 - $600 per year ($20 - $50 per month)
d. $600 - $1,200 per year ($50 - $100 per month)
e. More than $1,200 per year ($100 per month)

Participants were given options of appliances and electronics to choose from to indicate additions to their households or increases in their usage in separate questions. They were also given the option to write in appliances and electronics in these questions. The appliances and electronics listed included:

a. Air Conditioning Units
b. Internet Connections
c. Heaters
d. Kitchen Appliances
e. Entertainment Devices
f. Lighting
g. Fans
h. Televisions
i. Refrigerators or Freezers
j. Phones or Computers
k. School or Office Devices
l. I did not add anything new to my household
m. Other…

The sample applies to the greater population of low-income single-family home residents who have had solar panels installed through GRID's programs in the same timeframe. This population experiences the same climate and economic conditions as the sample.

4. Results

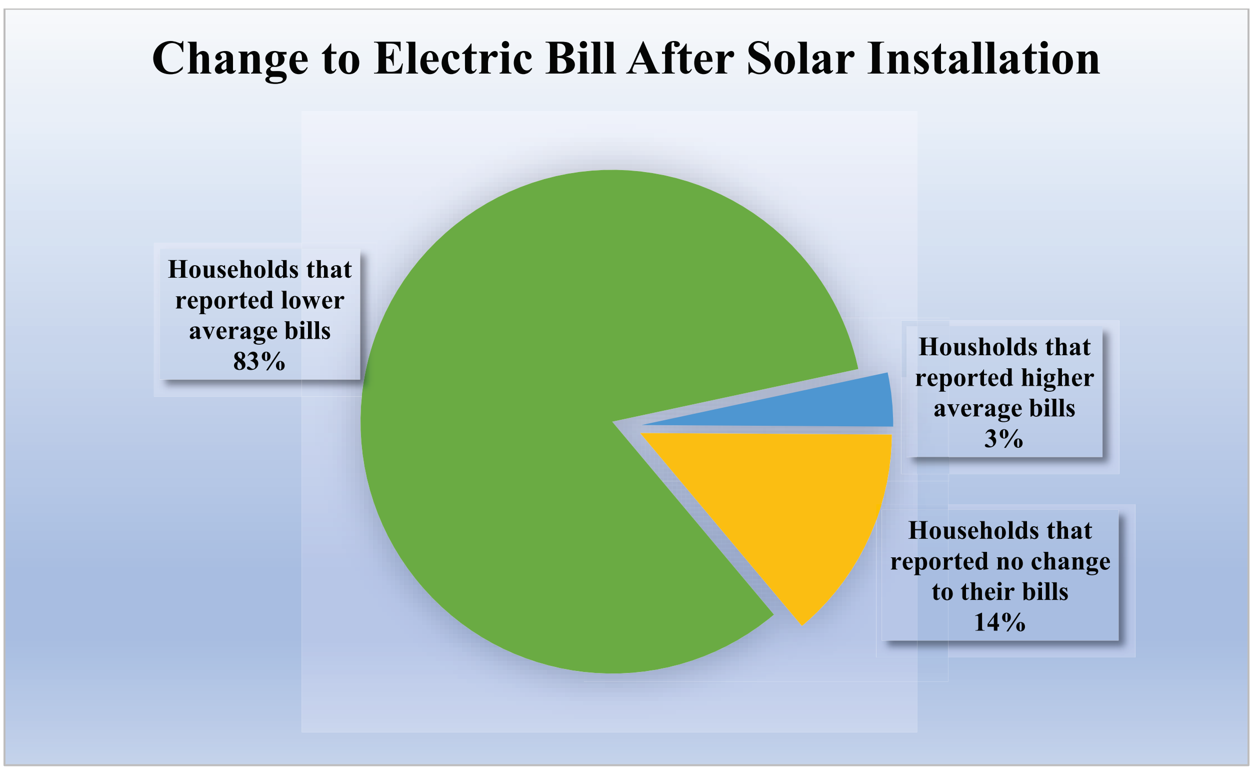
The results are based on a convenience sample of 87 households. 76 respondents preferred to respond in English and 11 respondents preferred Spanish [Table 1].

Table 1, Language profile

Language	English	Spanish
Residents	76	11
Percentage	87%	13%

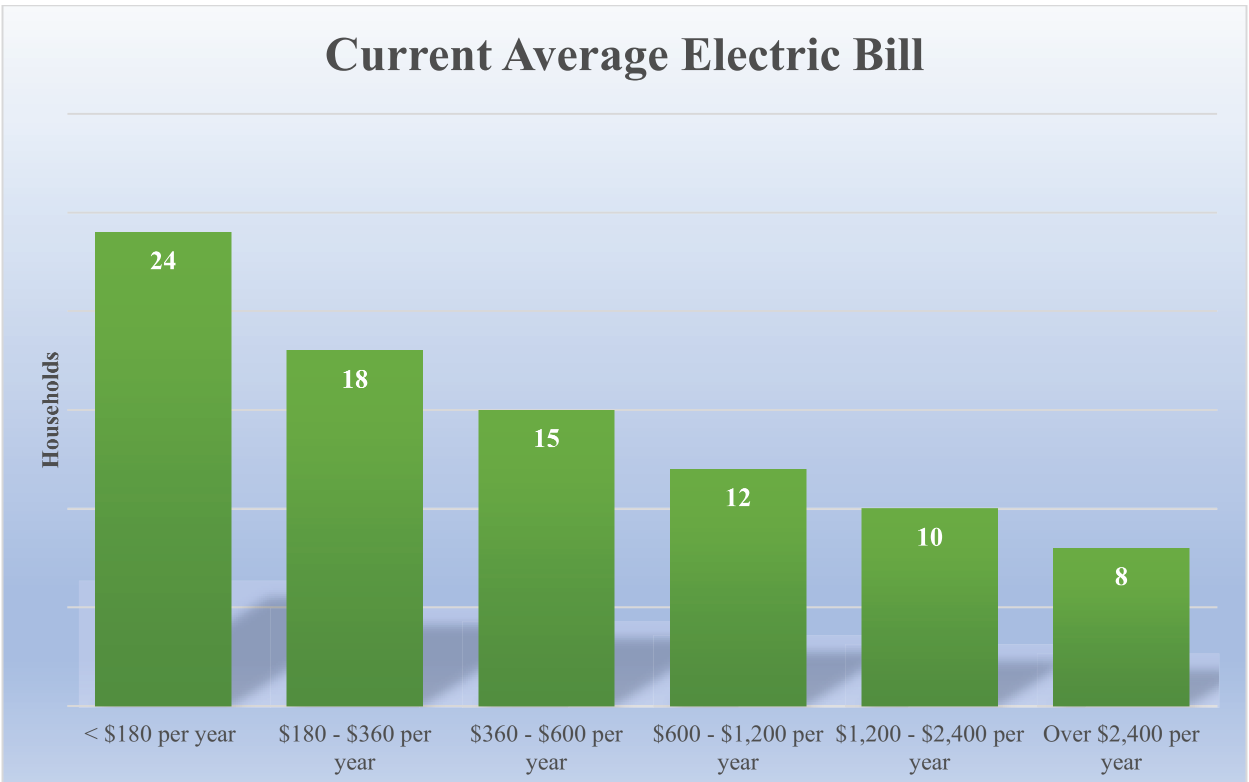
83% of residents reported that their electric bills were lower on average. 14% of residents reported no change to their electric bills and 3% reported an average increase to their electric bills [Table 2].

Table 2, Payment change



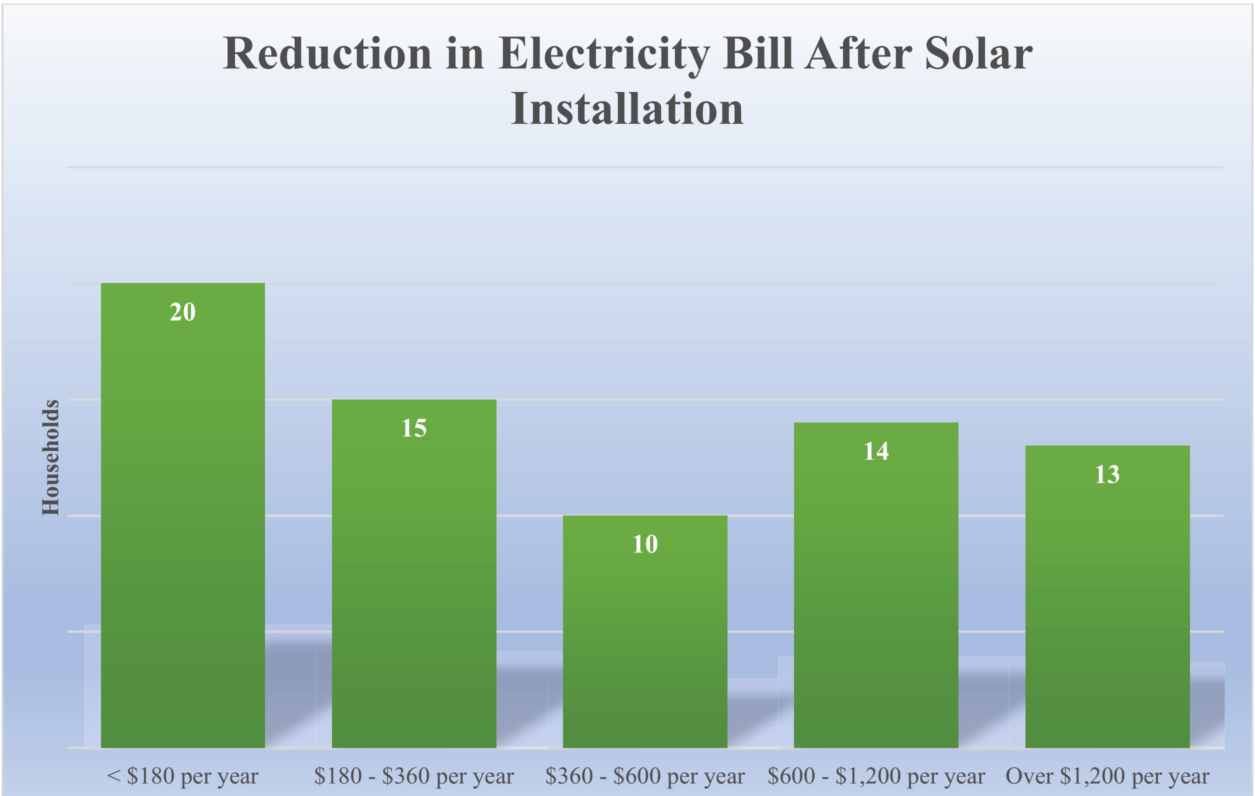
Residents reported a normal distribution of their average annual electric bills with a statistical mode of <$180 per year [Table 3].

Table 3, Payment amount



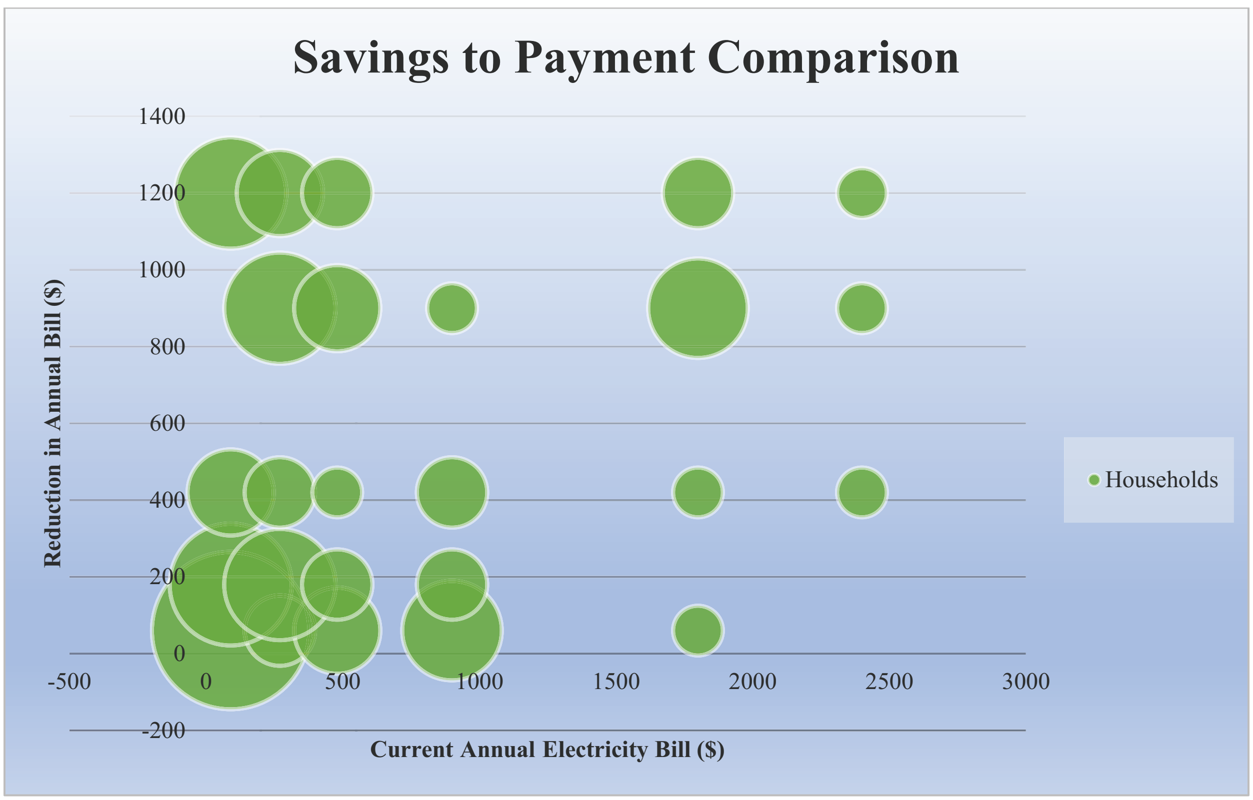
The greatest number of residents saw a reduction of <$180 annually from their electric bills followed by $180 - $360 annually, and then $600 - $1,200 annually [Table 4].

Table 4, Bill savings



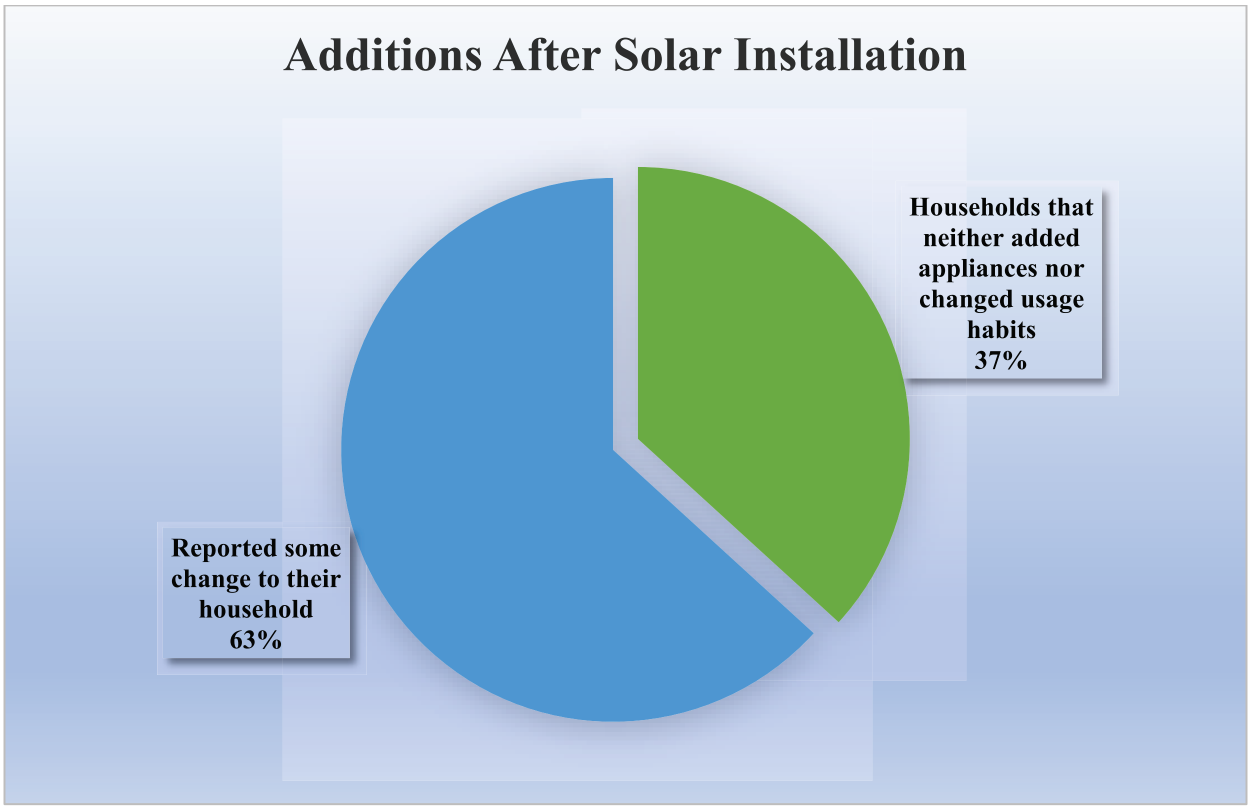
This chart combines the reported savings with the reported payments for each individual household [Tables 3. 4]. The top left corner reflects households that saw dramatic savings and now have low electric bills. The top right corner reflects households that saw dramatic savings but still have high electric bills. The bottom right corner reflects households that saw moderate savings and have still have high electric bills [Table 5]. And the bottom left corner shows households that saw moderate savings and now have low electric bills. The results of the survey show clusters in the bottom left corner and the top left corner: households saw moderate savings and now have low electric bills, and, households saw dramatic savings and now have low electric bills [Table 5]

Table 5, Savings vs. Current bill by household



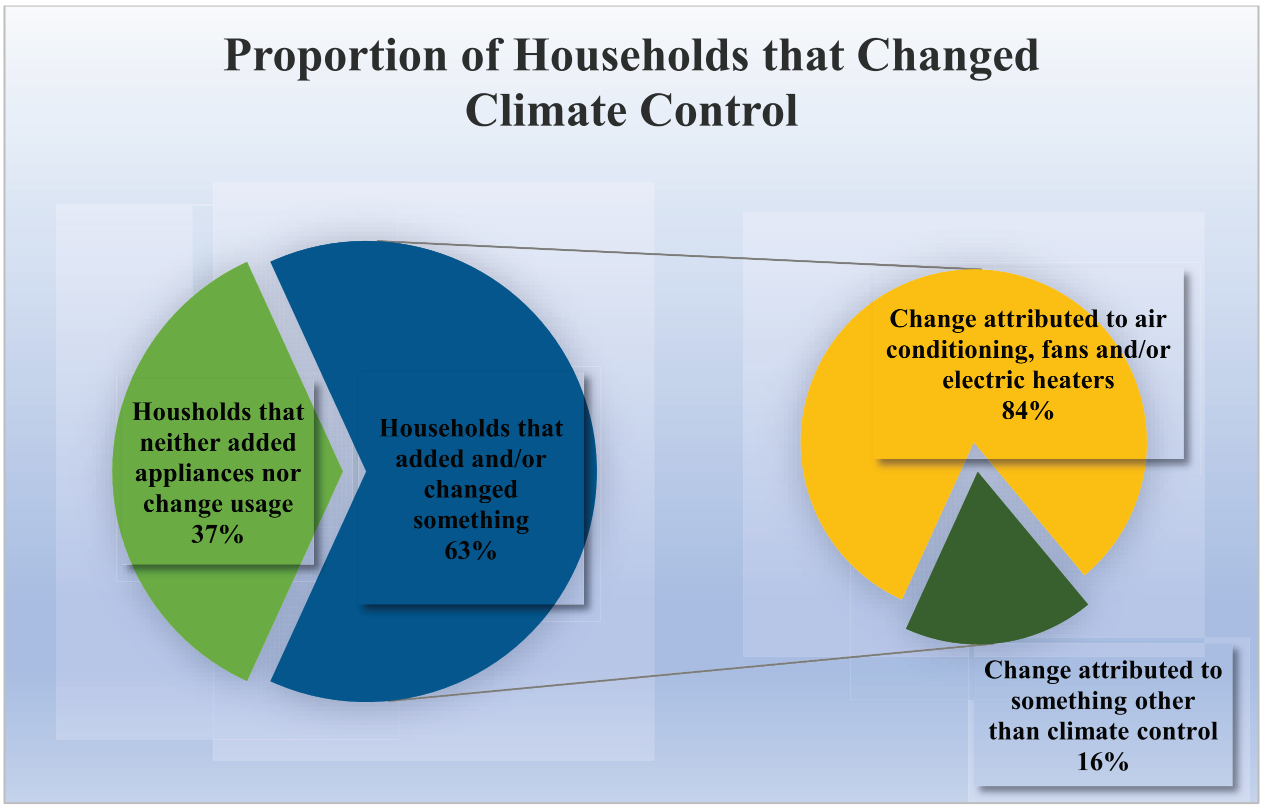
Of the 87 households, 63% stated that they either added appliances to their households or increased their usage of appliances after their solar panels were installed [Table 6]. Of the total households, 37% stated that they neither added any new devices nor changed their usage of existing devices after their solar panels were installed [Table 6].

Table 6, Post-installation behavior



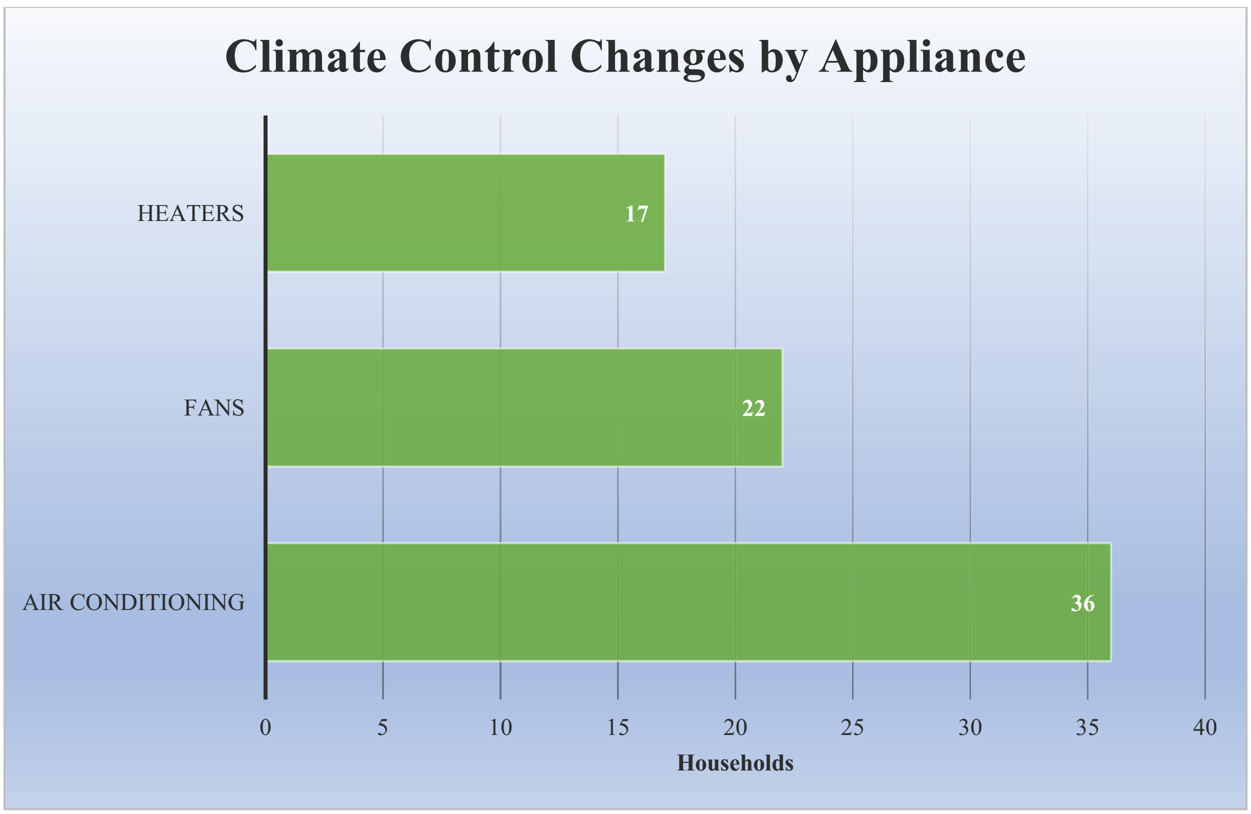
Of the 63% of residents who did add appliances or change their habits, 84% attributed that change to climate control devices in at least one form (air conditioning, fans and/or electric heaters) [Table7]. Of the households that changed something, 16% attributed the change to something other than climate control devices [Table 7].

Table 7, Climate control proportion



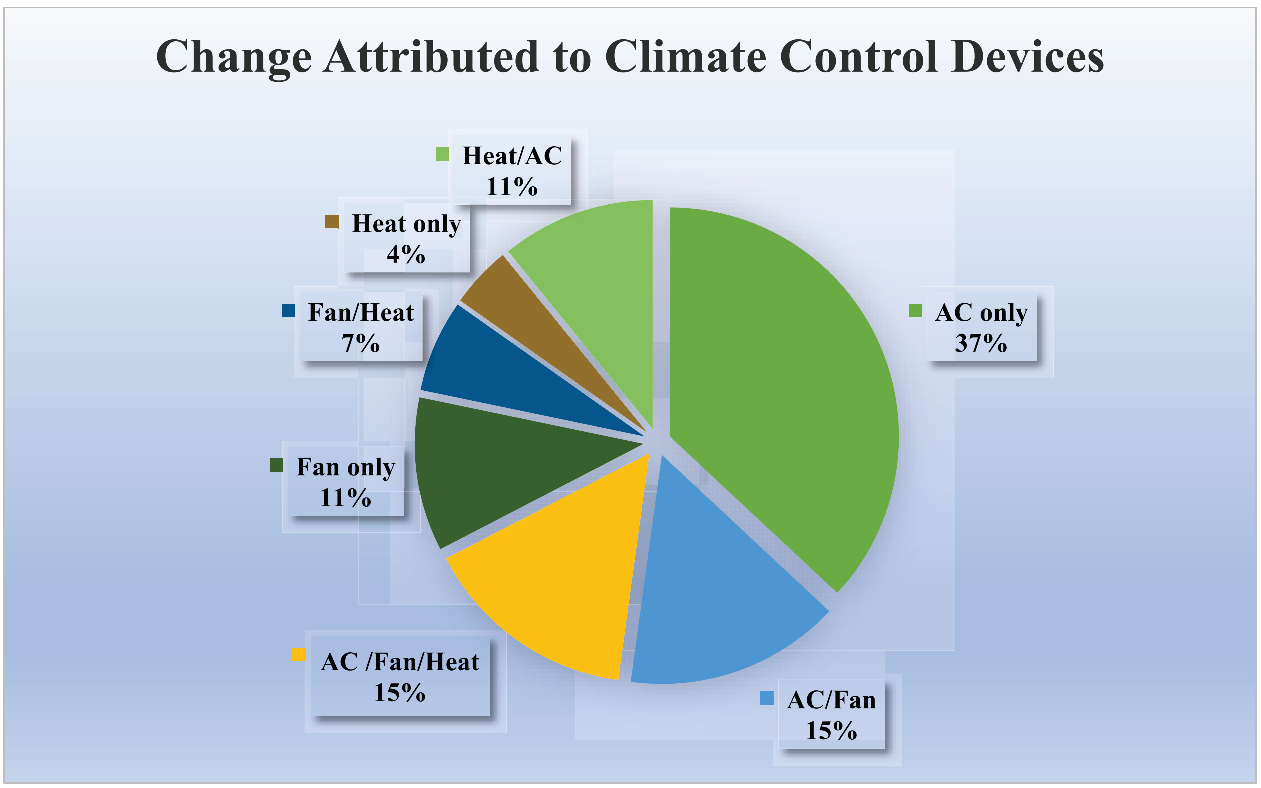
Of the climate control devices, households attributed the change most frequently to air conditioning [Table 8]. Air conditioning was increased or added in 36 out of the 87 households that participated in this study [Table 8]. Fans were used more or added to 22 households of the 87 [Table 8]. Heaters were added or used more in 17 of the households [Table 8].

Table 8, Climate control totals



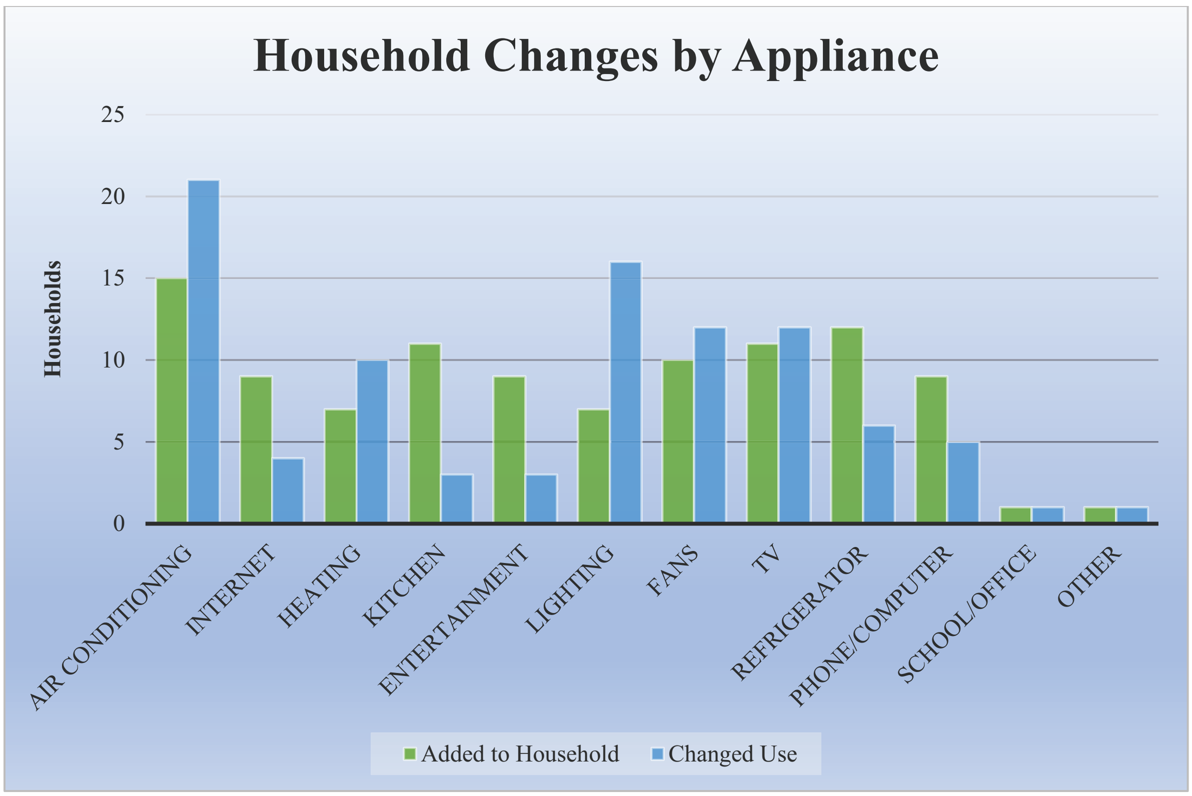
Of the households that added or changed their climate control devices, some households had overlap among more than one device [Table 9]. Most frequently residents attributed the change to air conditioning only, then air conditioning/fans, air conditioning/fans/heaters and air conditioning/heaters [Table 9]. All the air conditioning categories lead all other climate control categories [Table 9]. The air conditioning categories make up 78% of the change attributed to climate control devices.

Table 9, Climate control categories



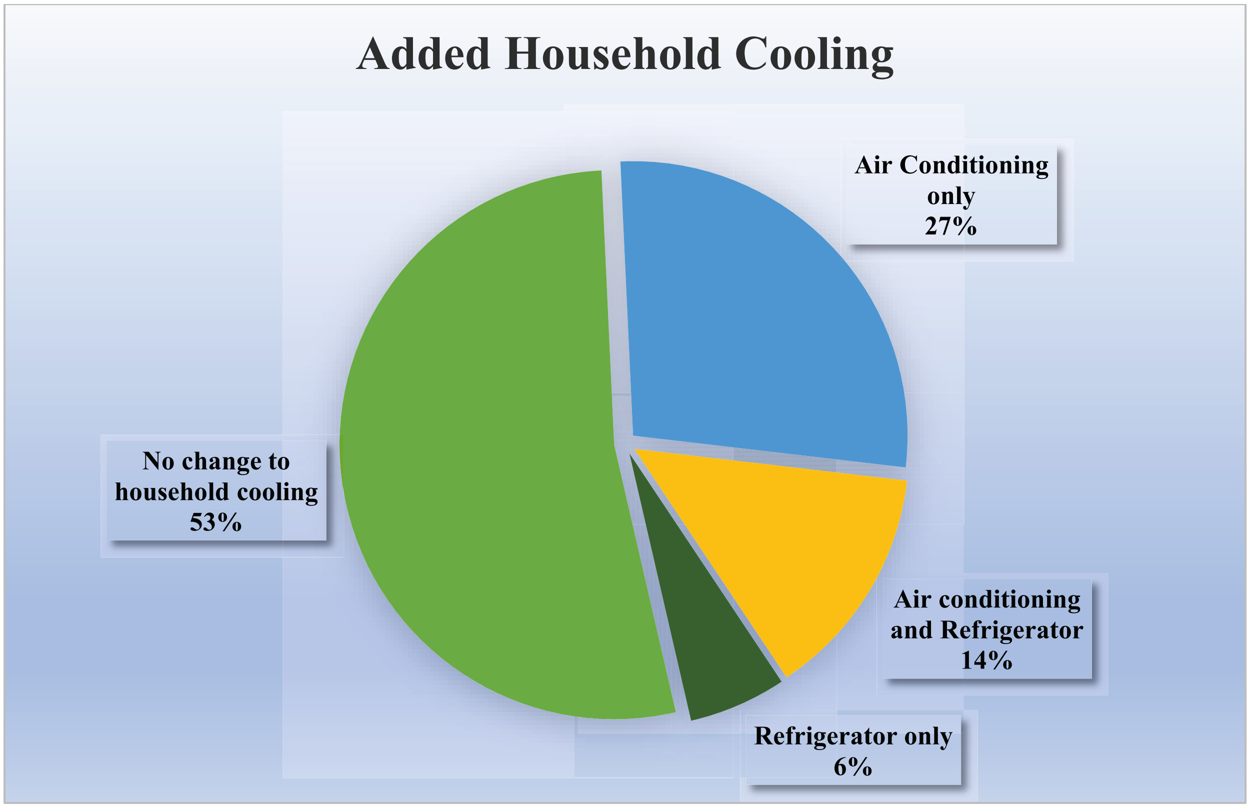
The survey compared household additions to increased use of existing appliances [Table 10]. The results of the survey show that the most common addition to the households was air conditioning compared to other appliances. Air conditioning was also the most prevalent appliance of which residents increased their usage [Table 10]. Increased use of lighting was the second highest category after increased use of air conditioning [Table 10].

Table 10, Appliances



Of the total households surveyed, 47% added or increased their use of a device that contains refrigerants (air conditioners or refrigerators/freezers) [Table 11]. Of total households, 27% attributed the change to air conditioning, 6% attributed it to refrigerators only and 14% attributed it to air conditioning and refrigerators [Table 11].

Table 11, Refrigerants



5. Discussion

The study shows that some outcomes are more likely than not after GRID installs a solar panel system for a household. Financially, the households are more likely than not to feel a decrease in their average electricity bill with 83% reporting a decrease in their bills [Table 2]. The data also shows frequent occurrence of residents paying less than $15 per month after a wide range of payment decreases [Tables 2, 4]. Many households in the GRID programs feel their payments drop by more than 50%. [Table 5] This result is in line with general findings on distributed solar installation (Center for Social Inclusion, et. Al., 2019). This finding supports an assumption of this study's hypothesis, that residents would experience lower electricity bills after solar installation.

A small proportion of the residents reported stagnant or increased bills [Table 2]. GRID monitors the systems after installation, so it is unlikely that these responses were due to the panels malfunctioning. Other potential reasons for the stagnant or increased bills could include 1) a rebound effect in which residents started using more electricity since it was coming from a renewable source 2) residents increased their awareness of their electricity bills after going through GRID's program, and resultingly these residents felt their bills had increased when they had not. These reasons could be explored by interviewing residents about their awareness in combination with analyzing utility bill data directly.

The study also shows that in a lifestyle capacity, households are more likely than not to change an aspect of their household after the installation of their solar panels [Table 6]. Of the total households, 63% reported some change [Table 6]. This means that not only do GRID's programs affect greenhouse gas emissions and households' average electric bill, but they also effect the lifestyles of the residents in some way.

The majority of changes were attributed to climate control devices with 84% of the housholds that reported a change attributing that change to at least one climate control device [Table 7]. In contrast, only 16% of households that reported a change did not change their climate control [Table 7]. This finding supports the study's hypothesis.

In the study, the most frequent appliance that the climate control change was attributed to was air conditioning, either as a newly added appliance or by residents increasing their use of an existing air conditioner [Table 8]. Air conditioners were also used in conjunction with other climate control devices such as heaters and fans, but not as frequently as air conditioning alone [Table 9].

This has interesting implications both for residents and for the environment. For residents, households can anticipate the ability to better regulate ambient temperatures in their households when they install solar panels. Given the anticipated increase in average temperature in Los Angeles County, especially in these neighborhoods, GRID installments could therefore be considered adaptation measures as well as mitigation strategies for climate change as residents use their renewable energy on climate control devices, with cooling devices outnumbering heaters (Hall, et. Al., 2015). However, further study would be necessary to determine if residents are adapting to climate change-induced warming, or merely coping with the current warm temperatures that these neighborhoods experience. In either case, access to reasonable ambient temperatures provides a public health benefit to the vulnerable populations in this county (County of Los Angeles Public Health, 2019).

In addition to the increase in air conditioning a notable change to the surveyed households was their reported increase in household refrigerants (air conditioners, refrigerators/freezers) [Table 10]. Nearly half of households added or increased use of at least one of these appliances, at 47% [Table 11]. The addition of air conditioners and refrigerators to households indicates an area where the Energy for All Program may cause a negative environmental impact.

Both air conditioners and refrigerators contain similar chemical substances to achieve cooling — they contain refrigerants (Department of the Environment and Energy, 2019). Two potential negative effects come from refrigerants. One, some refrigerants cause ozone depletion in the upper atmosphere when the chemical substances are released (Department of the Environment and Energy, 2019). The scientific community reached the consensus that the Ozone Hole is caused by anthropogenic emissions of ozone-depleting coolants and aerosols (Department of the Environment and Energy, 2019). Emissions from air conditioners or refrigerators can come from any stage of the appliance — manufacturing, installation, use, maintenance or disposal (Department of the Environment and Energy, 2019). International laws have pushed for ozone-depleting refrigerants to be replaced by other refrigerants, but depending on the year, company and area of manufacture, appliances that are currently in use contain different coolants.

For air conditioning, this draws a distinction between the GRID homeowners who added an air conditioner rather than increased the use of an existing one [Table 10]. Assuming the people who added air conditioning units added new ones, those residents likely installed units that meet modern regulations on ozone-depleting substances. However, the single most reported change in all households was people using their existing air conditioners more [Table 10]. The health and specifications of these air conditioners are unknown, with older ones being more likely to contain banned chemicals, leaks, or both.

The other negative consequence of refrigerants other than ozone depletion is greenhouse gas emissions, as some refrigerants are also synthetic greenhouse gases (Department of the Environment and Energy, 2019). Certain coolants are significantly more potent than carbon dioxide and can negate the avoided warming effect from changing energy sources if released into the atmosphere. For example, freon, which was once a very common coolant, is 1,810 times more potent than carbon dioxide (Department of the Environment and Energy, 2019).

Similar observations can be made about residents who purchased new refrigerators. New refrigerators that replace old substandard refrigerators is a positive environmental benefit. Notably, an interesting data point exists within the households that reported an increase in use of existing refrigerators [Table 10]. Since refrigerators typically run continuously at consistent energy levels, a further study or interviews should be conducted to investigate how residents *increased* the use of their existing refrigerators. Perhaps some households were in the practice of unplugging their refrigerators to cope with high electricity bills (Murkowski and Scott, 2014). Or perhaps some residents set their refrigerators to a higher than normal temperature. This data point highlights a lapse in construct validity of the study.

The study shows a correlation between solar panel installations and an increase of energy resources allocated to climate control. This finding illustrates an opportunity for further research to determine if low-income solar programs have direct causation: changes in household climate control being caused by the solar panels. Further research could employ interviews with homeowners to determine how they decided to change their usage.

With reviewed literature indicating an overlap between the population that low-income solar programs target and those that are energy insecure, and with literature indicating that the manipulation of climate control devices is a main coping technique, the study's findings also indicate that the study should be replicated in a colder city where energy savings may be rerouted to heating (Cook and Shah, 2018). The ability for this study to apply to further research in this same population or in other low-income communities bolsters its external validity.

If the findings of future research indicate that a main benefit to the solar panels is increased access to climate control devices, along with the analysis that these installations are in neighborhoods that are exposed to unhealthy temperatures and that these programs have some overlap with vulnerable populations, an argument can be made that the programs further address a public health inequity. This study cannot conclusively make that claim, discovering correlation rather than causation, but findings do indicate that further research is warranted in this area.

There are two areas of potential weakness with this research. One weakness may exist in the form of measurement error because results are self-reported. Participants at this stage have been educated on energy issues and know that energy conservation is important to GRID. Therefore, there may be underreported data due to social desirability. Another weakness is that distributed solar is not completely mainstream in American culture. Those that participated in this survey may be considered early-adopters on a national scale. The results therefore could contain a ceiling or floor effect, since these participants may hold significantly different attitudes and awareness than the average population.

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